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ABSTRACT

This pamphlet discusses career and employment opportunities in chemical engineering. Necessary college preparation is described and median salaries by degree are tabulated. Nontraditional careers in chemistry are also described. Future demand for chemists and chemical engineers is projected to 1985 and the availability of jobs for women and minorities is examined. (MI)

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CAREER OPPORTUNITIES IN CHEMISTRY AND CHEMICAL ENGINEERING

by Trienne Glover*

During the recent economic recession, career opportunities in chemistry and chemical engineering held up much better than did opportunities in most other fields. Students choosing careers, and colleges and universities planning for curriculum revisions and physical plant alterations, should note that employment opportunities in chemistry look relatively good through 1985. The employment of chemists is expected to grow faster than the average for other occupations during this period.

This positive outlook assumes that government and industry expenditures for research and development will continue to increase but at a slower rate than in the 1960's. Increased demand for plastics, manmade fibers, drugs, and fertilizers, in addition to increased interest in health care, pollution control, and energy, will contribute to the need for additional chemists and chemical engineers.

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The Employment Picture

Though the demand for chemists is not as great at it was a decade ago, the job market for chemists is far better than the overall job market. In March, 1976, the unemployment rate for chemical professionals was 1.9% compared to 8% for all workers. Academic positions are scarce, however; therefore, most employment must be sought in industry and government.

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If the current rate of entry into the chemical profession continues, an average of about 10,000 bachelor's degree graduates in chemistry would be needed annually over the 1974-85 period to meet projected requirements. Projections of the National Center for Education Statistics indicate an average of nearly 10,100 bachelor's degrees granted annually in chemistry over this period.

Though it is not possible to predict accurately the state of the economy for several years into the future, the following figures are based on the best available indications:[1]

Employment, 1974	135,000
Projected 1985 requirements	173,000
Percent growth (1974-85)	28.6
Average annual openings (1974-85)	10,000
Growth	3,500
Replacements	6,500

Available Degree Data:

DEGREES	1973-74	PROJECTED ANNUAL AVERAGE 1974-85
B.S.	10,517	10,064
M.S.	2,095	2,076
Ph.D.	1,760	1,507

Though employment projections look good in general, some chemists with advanced degrees may have to take employment that does not utilize their training fully. The Bureau of Labor Statistics estimates that "if past degree trends continue, the supply of Ph.D. chemists in 1985 will climb to 47,100, with the demand totaling only 43,300. . . an excess of 8.1%."[2] Though this appears a substantial oversupply, other Ph.D. scientists will be in much greater oversupply, mainly because of the projected shortage of academic jobs. The actual unemployment rate for Ph.D. chemists is expected to be quite low, however, because of the phenomenon of job upgrading or job enrichment: employers will hire Ph.D.'s to fill jobs formerly held by M.S. or B.S. chemists. Therefore, the Ph.D. chemist is much more likely to be underemployed than unemployed. During any job crunch, the greatest difficulty in finding jobs will fall to the B.S. chemist.[3] One way to prevent such a "bumping" situation from affecting the job opportunities of B.S. chemists is to broaden their education (see page 6).

Of all chemists employed in 1970, reports the National Science Foundation, private industry employed 62%; colleges and universities employed 24%; federal, state and local governments employed 8 to 9%. About one-half of all chemists were working in research and development in 1970; 12 to 15% each were in teaching, production, and management. Private industry employed 70% of the chemists with bachelor's degrees, 61% of

[1] Occupational Projections and Training Data, 1976, Bureau of Labor Statistics Bulletin 1918, p. 50.

[2] Howard J. Sanders, "Supply and Demand for Chemists," Chemistry and Engineering News, July 4, 1977, p. 19.

[3] Ibid., pp. 19 & 29.

those with master's degrees, and 51% of those with doctoral degrees.

Chemists at the Bachelor's level held most of the jobs in production, inspection, development, and general management. Chemists with doctoral degrees dominated teaching, basic and applied research, and development. Chemists constitute the largest group of physical scientists employed by the federal government. The 8000 chemists employed during 1976 worked in many Federal agencies and departments.[4]

Chemists are employed in all parts of the country, but are concentrated in large industrial areas. Nearly one-half of the total work in six states: New York, New Jersey, California, Pennsylvania, Ohio, and Illinois. Nearly one-fifth of all chemists are located in four metropolitan areas: New York City, Chicago, Philadelphia, and Newark.

The Work of the Chemist and Chemical Engineer

The largest numbers of chemists work in chemicals and allied products. Other areas include food; textiles and apparel; lumber and furniture; paper; petroleum refining; rubber; stone, clay and glass; primary and fabricated metals; machinery; electrical equipment; motor vehicles, air craft and other transportation equipment; ordnance; professional and scientific instruments; mining; construction; transportation; public utilities; and teaching.

Clinical chemists work in hospital laboratories carrying out tests and developing new tests to detect diseases, inherited disorders and other abnormalities. Biochemists work in nutrition, determining the nutritive value of foods, analyzing food products, investigating the effects of cooking and canning on nutritive values of foods, monitoring fermentation in breweries and other fermentation industries, etc. Biochemists also work in agriculture in animal nutrition, crop cultivation, processing and storage of commodities, pest control, etc. They work in pharmaceuticals and many other industries.

Chemical engineers convert chemical knowledge developed in small-scale research and development laboratories into large-scale production in industrial operations. They design plants and supervise construction of large-scale equipment and oversee the production, purification and delivery of large volumes of chemicals. Chemical engineers also work in process design and evaluation and pilot plant or semiworks construction and operation. A chemist or chemical engineer can advance in administration, sales and other business areas within the chemical and related industries. The B.S. in chemistry is a good background for entering other professional training programs as well, such as medicine, pharmacology, veterinary science and law. To teach in college or conduct research programs, one should have a master's or preferably a doctor's degree.

There are many other employment areas in chemistry not traditionally associated with the field but which involve a thorough knowledge of chemistry combined with expertise in another discipline.

[4]"Careers in Chemistry Today" (Booklet), American Chemical Society, Washington, D.C., 1976, pp. 3 & 15.

Commercial Development
(taking an intermediate or end product of some other process and developing it until it can be made and sold economically in a form that fills some human need)

Banking
(helping to serve corporate customers who are in the chemical and chemical process industries, evaluating proposed loans to client chemical companies, etc.)

Patent Law
(securing patents to protect a company's products and processes, obtaining legal use of other companies' patents to promote development of new products)

Writing
(writing and editing chemical books, journals, and articles for newspapers, wire services, and magazines)

Information Science
(managing, storing and retrieving scientific and technological information that chemists must have in research, academe, and government; developing such information systems)

Forensic Chemistry
(analyzing evidence in crime laboratories)

Industrial Hygiene
(protecting workers from overexposure to contaminants and other stresses in the work environment; measuring concentrations of airborne dust, sprays, vapors, etc.; devising necessary protective measures)

Museums
(authenticating documents, paintings, etc.)

Business
(studying markets for various products, arranging financing for chemical ventures, building plants, testing products for quality, etc.)

Toxicology
(determining potentially adverse effects of chemicals on biological systems - involves pollution, drug abuse, food additives, detergents, etc.)

Clearly, beginning chemical professionals need to be flexible in their career plans as new opportunities in emerging fields increase the range of jobs for chemists and chemical engineers.

[5]Ibid., pp. 16-18.

Salaries

The salaries earned by chemists at all degree levels have increased steadily since the early 1960's, according to data compiled by the American Chemical Society. In 1974, however, inflation erased the buying power of the increases that had come since 1969, and further erosion occurred in 1975. Chemists' salaries vary widely depending on degrees, employer, work activity, geographic area, experience, and ability. In 1975, the lowest median salaries were reported by B.S. chemists in the teaching profession, who earned $10,700; the highest were reported by Ph.D. chemists in management, who earned $30,000.

The American Chemical Society 1977 Salary Survey shows the following median salaries for ACS members. (Members of ACS tend to have slightly higher salaries than other chemists and chemical engineers largely because ACS members tend to be among the older, more experienced, and more established chemists and chemical engineers.):

CHEMISTS' MEDIAN SALARIES

	1973	1974	1975	1976	1977
B.S.	$16,800	$17,500	$19,000	$19,800	$21,000
M.S.	17,500	18,400	19,800	20,500	22,000
Ph.D.	20,500	21,700	23,000	24,700	26,000

CHEMICAL ENGINEERS' MEDIAN SALARIES

B.S.	$20,200	$21,300	$24,000	$26,000	$28,000
M.S.	22,000	22,400	25,000	27,000	30,000
Ph.D.	23,100	24,800	26,000	29,000	30,000

Inexperienced B.S. degree graduates in chemistry receive average starting salaries of about $11,669. Since chemical engineers with B.S. degrees have not been graduated in near the numbers that have been needed for the past 20 years, inexperienced chemical engineers commanded starting salaries in 1977 of around $16,565 and have more job offers to choose from than chemists. Industrial emphasis on the practical explains, in part, the almost continual shortage of chemical engineers, 80% of whom work in industry.

In 1972, when the last complete survey of chemical technicians was made, salaries in industry for technicians ranged from $6,500 to $11,000 (average -- $8,500); in Federal agencies salaries began at $6,100, $6,900, or $7,700. In a survey made by the American Chemical Society in 1977, very few schools of chemical technology reported starting salaries below $10,000 for their graduates. Some companies have removed the ceiling

from the salary of the chemical technician, and their outstanding technicians can earn more than $18,000 per year.

Discrimination and Affirmative Action

For many years, discrimination in the chemical field discouraged women and members of most minorities from entering the profession. Those that did enter were more often than not "kept out of the upper reaches of what has been essentially an occupation for white males. The size of the profession, about 200,000, and the relatively slow turnover of the personnel prevent any immediate or even rapid righting of the wrongs of past years. Women and minorities, especially blacks, will remain underrepresented in chemistry for decades to come. However, there are clear signs that efforts are being made -- particularly for new entrants into the profession -- to improve the status of these groups. The employment outlook for blacks and other minorities in chemistry has improved significantly in the past decade, especially for those with B.S. degrees."[6] According to Dr. Ronald Brooks, a black research manager for General Electric, "Any reasonably qualified minority chemist has an excellent chance of finding a job today in the chemical industry and this situation is bound to continue as long as the nation's overall employment picture remains good."[7] Government regulations barring discrimination against minorities account for most of the improvements in the hiring of women and minorities, Dr. Brooks states.

Chemistry Education

A career in chemistry or chemical engineering can be started at any of several educational levels. With a high school diploma, one may be able to work as a laboratory assistant. With an associate's degree in chemical technology, one could become a chemical or chemical engineering technician. The domain of the chemical technician is practical, not theoretical work. Chemical technicians are in short supply in most areas. Only 600 to 800 chemical technicians graduated from A.S. programs in 1972, and figures for more recent years are about the same. Since there is only 1/2 technician for each scientist or engineer, some companies take high school graduates, especially technical high school graduates, and train them to work as chemical technicians. Ideally, there should be at least two technicians for each scientist or engineer. Technicians carry out chemical analyses, compute, tabulate, compare and analyze results, and make chemical and instrumental measurements to determine characteristics of substances. They keep precise and detailed records, and make reports, tables and graphs.

Getting a bachelor's degree opens up many more career possibilities. The B.S. degree in chemistry is the route to laboratory jobs in analysis, research and development, or other technical areas which include much independent work. It is not the intent of the American Chemical Society's Committee on Professional Training to establish uniform

[6] "Women and Minorities in Chemistry, '75," Chemistry and Engineering News, Vol. 52 (Oct. 7. 1974), pp. 34 - 36.

[7] Ibid.

programs of chemistry across the nation; however, according to the Committee, in order to train competent and competitive B.S. graduates, a chemistry department should have sufficient lecture rooms and office space, student instructional laboratories as well as faculty and student research laboratories, a good library that includes foreign periodicals, resource rooms and self-learning centers, modern equipment and instruments, and a safety program. The Committee also recommends that an undergraduate chemistry curriculum include fundamental chemistry courses, mathematics, physics, physical chemistry, foreign languages, communication, advanced work, interdisciplinary programs, laboratory work, independent study and research, cooperative work-study, and internship programs.[8]

The favorable job market for engineers and technologists strongly suggests that one useful change in undergraduate chemistry education would be to incorporate engineering and practical technology into the curriculum of chemistry majors. Counselors in chemistry education familiar with the employment market urge that all undergraduate chemistry majors be required to take courses in chemical engineering.

Unfortunately, "Much of our present undergraduate chemistry curriculum seems designed to prepare students for graduate school rather than for a job in industry or elsewhere. Since relatively few B.S. chemists go into research, students should be given a wider choice."[9] Qualitative and quantitative analysis, organic and inorganic chemistry, and instrumental analysis are courses that should be taken by undergraduate chemistry majors, say chemistry career advisors. Many B.S. chemists could find jobs in analytical labs if more undergraduate programs offered analytical chemistry. B.S. graduates need laboratory training in preparative inorganic and organic chemistry. Frequently, employers have complained that their new B.S. chemists seem almost lost in the laboratory. Therefore, it is recommended that undergraduates take at least 500 hours of laboratory in chemistry, learning a variety of lab techniques.[10]

Students often do not realize that the ability to communicate clearly is essential in the chemical profession. "Formal courses in English composition provide a valuable start in learning effective communication but are not enough. Continual practice and criticism are necessary to develop skill and experience in oral and written scientific presentation, as well as graphic and pictorial presentation."[11] Teachers of chemistry should stress student development of communicative skills as well as the comprehension of chemical theory and laboratory techniques.

Emphasis on pure theory has too often led to a neglect of the practical, aesthetic, and humanistic aspects of chemistry. Not only in courses for non-scientists but in the education of professional chemists as well, the relationship of the science of chemistry to people, nature and everyday life situations should be stressed.

Of course, no 4-year curriculum can cover everything of value to a future chemist. However, any B.S. graduate in chemistry should be confident in his or her ability to:

[8]"Objectives and Guidelines for Undergraduate Programs in Chemistry" (Booklet), American Chemical Society Committee on Professional Training, Washington, D.C., 1972, pp. 3 - 10.

[9]Sanders, p. 30.

[10]"Objectives. . .," p. 5.

[11]Ibid., p. 4.

Perform quantitative mani pu lations
Assess the reliability of work
Handle statistical analyses of data
Use effectively and with understanding a good selection of modern instruments
Plan experiments through use of the literature
Observe standard safety measures
Keep adequate experimental records
Write good reports[12]

Undergraduate education for a successful career in chemistry requires both breadth and some specialization. And, contrary to the belief of many, students on the graduate level can seriously limit their job opportunities by overspecializing in one area of chemistry. Graduate training, too, should be as broad as possible so that a person does not become locked into one type of work.

For the qualified, dedicated and flexible chemist, chemical technician, or chemical engineer, career opportunities in the fields of chemistry and chemical engineering are substantially more numerous and financially rewarding than in most other science fields and appear sure to remain so through the next several years.

[12]Ibid., p. 6.

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